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Agricultural Research

Foretelling Soil Erosion

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Sixty Years of Conservation Research

Next year will mark 60 years of research by the U.S. Department of Agriculture into the causes and cures of soil erosion. The program began in 1929 with passage of the Buchanan Amendment, which appropriated the first funds for soil erosion investigations and established eight regional soil erosion experiment stations.

The amendment was named for its author, Congressman James P. Buchanan, of Spur, Texas, who during House hearings in 1928, said that his bill would finance "experiments on different types throughout the agricultural sections of the United States for the purpose of keeping...water from running off, conserving it for the immediate benefit of the farmer, for the purpose of keeping it from washing away the soil and depleting it and ruining it forever...."

Rep. Buchanan added that the conquest of erosion seemed so important "that we neglect our duty if we do not attend it now."

The creation of those first conservation research stations, operated by the old Bureau of Chemistry and Soils, couldn't have been more timely. Between 1929 and 1933, severe floods damaged farms in the Southeast. In the Great Plains, a grasshopper plague combined with overgrazing and unrelieved drought to wipe out crops and crop residues for several years in a row. In the plains, the result was the worst duststorms in our nation's history and an out-migration of farmers and their families from farms that had become as unproductive as the Sahara.

In response to the growing damage to land, crops, and human lives, the Soil Erosion Service was created in 1933 and subsequently reorganized as the USDA Soil Conservation Service in 1935. This was an action agency, created to help farmers and ranchers apply what research scientists were finding out about erosion.

Some 9 million acres of the most critically damaged land lay in 20 counties in and around the Texas Panhandle—an area that became known as the Dust Bowl. Damage was so severe, in fact, that a number of specialists predicted that the land could never be reclaimed and would have to be permanently abandoned to agriculture.

Fortunately, a USDA researcher named H.H. Finnell disagreed with the pessimistic forecasts. Making his headquarters at Dalhart, Texas, in the heart of the Dust Bowl, he arranged for a long-term lease on 25,000 acres of land for use in experiments. It was land devoid of vegetation, with abandoned farmhouses half buried by windblown soil.

Step by step, Finnell and his associates developed reseeding methods for this wasteland and experimented with what he called "trashy farming," the forerunner of modern conservation tillage methods that leave the residue from the previous crop on the surface of the soil to slow down erosion.

But it was a long, hard struggle. In the western Great Plains, where native grasses like the gramas and buffalograss had been eliminated either by overgrazing or by cutting away the sod to plant wheat, researchers found that the native grasses couldn't be coaxed into growing again, even when planted carefully by hand.

Then USDA plant explorers discovered a short, tough bunchgrass in southern Russia that could be planted like wheat. It was crested wheatgrass, and hundreds of thousands of acres in the U.S. plains were planted in it during the 1940's and early 1950's.

In the eastern Great Plains, another import helped hold the line against erosion from wind; it was bromegrass, brought to this country from Hungary.

Meanwhile, researchers kept trying to find out why native grasses wouldn't grow. Eventually, they learned that they didn't like to be pampered with soft, prepared seedbeds. They did best on hard ground, with plenty of stubble on top to keep seeds from blowing and to conserve moisture.

Researchers also learned patience. Native grasses of the prairie wouldn't grow up during the first year like other grasses. First they had to put down hairlike roots, searching for moisture, conserving their energy. Then, if the moisture was there, they grew up in the second year. Scientists and conservationists, in turn, taught farmers and ranchers to watch and wait.

Finally, the natives began to reappear. In the arid High Plains, blue grama and buffalograss came back, and on the eastern plains, little bluestem, switchgrass, Indiangrass, and big bluestem, or turkeyfoot. As a result of careful research, today there are more than 100 other grasses—some natives, some imports, some improved natives—all helping replace the centuries-old ground cover that was unwittingly destroyed by the first settlers.

Today, as we begin our 60th year of conservation research, the Agricultural Research Service continues to seek effective, economic ways to combat erosion, sedimentation, pollution, and other soil and water concerns. One abiding aim of our scientists is to make sure there is never again a repetition of that terrible waste of resources that occurred in the late 1920's and early 1930's.

M.E. Carter
Acting Administrator

Agricultural Research

Cover: On cropland near Cottonwood, South Dakota, ARS scientists conduct erosion research by collecting and analyzing the runoff produced by a rainfall simulator. Photo: Tim McCabe. (0887X840-33)

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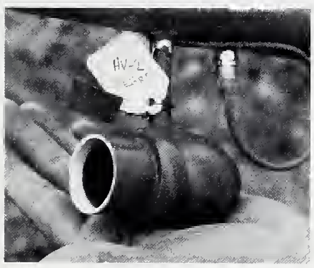

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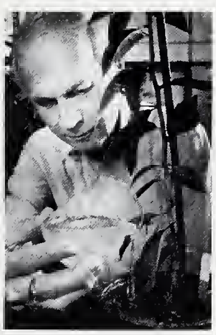

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Computers Fill a GAPP for Plant Explorers

Had King George III known that breadfruit would not thrive in England's colonial West Indies, Captain Bligh might not have sailed for Tahiti and the 1789 mutiny on the Bounty would never have taken place.

Now, nearly 200 years and several movie epics after Captain Bligh and the breadfruit were cast adrift, an Agricultural Research Service botanist is developing a computer program to bring about more fruitful expeditions.

"We call it GAPP—for Germplasm Acquisition Priority Program," says Alan A. Atchley of the ARS Germplasm Services Laboratory in Beltsville, Maryland. "When fully operational, it should help our plant explorers bring back the plant germplasm America needs most."

Plant germplasm is the stuff in seeds, spores, buds, and other tissue that transmits hereditary characteristics. To ensure the availability of important genetic traits such as insect and disease resistance for plant breeding purposes, vast collections of germplasm representing over 600,000 plant varieties are maintained in the United States by USDA and several states and many private institutions. These gene banks are replenished and expanded in large part by germplasm expeditions funded directly or indirectly by the government.

"But the expeditions can't cover everything," says Atchley. "So which germplasm and genetic traits get top priority? Is there, in effect, a critical gap in our inventories? That's the question GAPP addresses."

The program will let explorers check numerous U.S. germplasm collections for selected crops and genetic traits, see where the shortages are, and rate the importance of obtaining fresh materials from various countries.

"The ratings involve many criteria and an enormous amount of information," Atchley says. "That's where GAPP will really earn its keep."

Among the criteria are a crop's monetary value, its geographical distribution and that of its wild relatives, its susceptibility to disease, and the long-term viability of its seeds.

"Scientists and plant explorers can weight these and other factors however they see fit," says Atchley. "The main thing is that none of them will be overlooked in the decision-making process."

To illustrate how GAPP will work, Atchley offers the hypothetical case of a plant explorer from the United States going to the Middle East.

"There's a lot of genetic diversity in wheat and its wild relatives in the Middle East," he points out. "So here we have a potential gold mine for wheat germplasm. But the plant explorer doesn't necessarily have the expertise on wheat that a wheat specialist would have."

Through the use of GAPP, the explorer can find out in a few minutes which features in these diverse wheats are of current interest to wheat breeders back in the United States. The program would then survey U.S. wheat germplasm collections, call attention to the germplasm most needed from areas of the Middle East where the explorer was heading, and even suggest precisely where in the Middle East it might be found.

"Only later versions of the program will do that last bit about locating the wheat," Atchley says.

He expects early versions of GAPP to be ready for use by 1989.—By **Steve Miller,** ARS.

Alan A. Atchley is with the USDA-ARS Germplasm Services Laboratory, Room 307A, Bldg. 001, Beltsville, MD 20705 (301) 344-4423. ♦

Super Slurper Saves the Day for Good Nematodes

Body powder, batteries, and cold packs for injured bodies and picnic coolers have it; now soil in citrus groves could also receive a helping of a super thirsty, ARS-invented absorbent called super slurper. It seems that the absorbent keeps soil moist so tiny worms survive and kill weevils that chew up citrus tree roots.

Entomologist William Schroeder pours super slurper packed with beneficial nematodes that attack citrus root weevils around a young orange tree. (1187X1254-26)

In tests, the absorbent helped the soil worms—actually beneficial nematodes—kill 60 percent of citrus root weevils, compared to 25 percent without its help, says Agricultural Research Service entomologist William J. Schroeder.

Schroeder, based in Orlando, Florida, says that if unchecked, weevils can kill 20 to 30 percent of the trees in a grove and make others unable to produce fruit.

The nematodes, with the tongue-twisting names *Heterorhabditis heliothidis* and *Steinernema feltiae,* penetrate weevils' guts and release lethal bacteria. They don't harm plants or other organisms.

These nematodes haven't been used previously as natural weevil control because they die quickly if soil dries out.

Schroeder says, "I realized that to use this biological control, we would have to keep the soil moist." With its ability to hold up to 2,000 times its own weight in water, he figured super slurper would give him a way.

Other ARS scientists working at ARS' Northern Regional Research Center in Peoria, Illinois, invented the cornstarch-based super slurper in 1974. Schroeder is seeking a patent on his new use for the absorbent.

Commercial companies could mass-rear nematodes and package billions of them alive, he says. Growers could mix them with super slurper to put on citrus tree roots before planting. "What they would have then is a grove of trees with weevil control built-in around the roots—right where they need it."

For mature groves already inhabited by beneficial nematodes, Schroeder is looking into injecting super slurper into soil with a nozzle to make conditions more favorable for them.

Other ARS laboratories are testing the absorbent and nematodes to see how well the mix works to control pests of corn and vegetables.—By **Jessica Morrison,** ARS.

William J. Schroeder is at the USDA-ARS Horticultural Research Laboratory, 2120 Camden Road, Orlando, FL 32803 (305) 897-7300. ♦

Antiweed Bacteria May Replace Some Herbicides

Root-dwelling bacteria that attack weed seedlings could replace some chemical weed killers, says a scientist with the Agricultural Research Service.

These rhizobacteria multiply in microscopic crevices between the weed's root cells, says Robert J. Kremer, an ARS microbiologist based in Columbia, Missouri.

Kremer has identified several strains of rhizobacteria that attack velvetleaf, cocklebur, jimsonweed, pigweed, and morningglory. They break down root-cell walls or deliver toxins to leaves, cutting production of the chlorophyll a weed needs to convert sunlight into food energy.

"They may also interfere with a weed's hormones or make it more susceptible to stresses such as drought and disease," says Kremer.

"We don't know yet exactly how these rhizobacteria work," he added, "but eventually they could be a commercially feasible means of weed control that will allow less use of chemical herbicides."

Microcrevices between a weed's root cells can house 250 million weed-fighting microbes per inch of root, according to Kremer's electron microphotographs of 2-week-old seedlings.

In greenhouse tests with velvetleaf, a widespread pest of row crops such as cotton, corn, and soybeans, one rhizobacterium reduced top growth of 14-day-old seedlings by 88 percent, compared to uninfected plants.

In the tests, velvetleaf seedlings were dipped in a liquid suspension containing the rhizobacteria. Taproots of the infected seedlings averaged 1.7 inches long, compared with 3.9 inches for the controls. Lateral roots were shorter, too.

"To the weed, shorter roots mean less nutrients and water and greater susceptibility to stresses such as drought," says Kremer.

Although rainstorms washed out his 1987 field tests, Kremer expects to repeat them this year, to make sure that rhizobacteria won't harm crops. He also hopes to find out how many weed species each rhizobacterium is effective against and what toxins it uses to attack weed seeds and seedlings. These toxins might lead to new, safe weed-specific herbicides.

Kremer has also discovered that some strains of rhizobacteria cause weed seeds to rot. They are able to overcome the seeds' natural defenses—tough outer coats plus toxic chemicals that can ward off enemy microbes.

New tests show that rhizobacteria could get a boost from some commercially available pesticides, including the herbicide butylate and the insecticide carbofuran. Applied at very low rates, these compounds stimulate weed seeds to germinate. "As a seed prepares to do this," he says, "it releases nutrients that attract and nourish rhizobacteria—and some fungi—that attack the seed. Also, the sooner it germinates, the sooner roots develop and rhizobacteria can multiply in the microcrevices."—By **Jim De Quattro,** ARS.

Robert J. Kremer is in USDA-ARS Crop Production Research, Room 216, Waters Hall, University of Missouri, Columbia, MO 46211 (314) 875-5357. ♦

Small Tomato Pots Are Perfect Space Savers

Good news for people with a yen—but little room—to grow garden-fresh tomatoes. Growing tomatoes in 3 1/2-inch pots yields compact, space-saving plants and tomatoes that compare favorably to those grown in larger pots, according to an Agricultural Research Service scientist.

Donald T. Krizek, a plant physiologist for ARS at its Beltsville, Maryland, research center, says the plants can be grown by urban dwellers with windowboxes or small backyards. With regular watering and fertilizing, they grow to about one-half their normal size, yet produce average-sized tomatoes that taste as good as ones grown on regular-sized plants.

Krizek and colleagues studied plants grown in 3 1/2-inch and 11-inch pots. They grew Better Bush variety, an ideal plant for container culture because it remains fairly compact during growth.

After 12 weeks, plants in 3 1/2-inch pots averaged six tomatoes and those in 11-inch pots produced nine. In one sense, Krizek says, they outyielded the normal-sized plants since nearly three times as many plants can grow in the same space.

He says the plants are dwarfed because roots in small pots become densely branched and matted. This could result in reduced uptake of nutrients and less plant growth.—By **Doris Sanchez,** ARS.

Donald T. Krizek is in the USDA-ARS Plant Stress Laboratory, Room 206, Bldg. 001, Beltsville Agricultural Research Center, Beltsville, MD 20705 (301) 344-3143. ♦

Farmers Look to Science for Anti-Erosion Plan

"Bluegrass forms a heavy sod that helps to build up the soil and keeps it from washing away," says wheat grower Carroll Schultheis. Looking out over the steep hillsides of his farm in southeastern Washington, he recalls when he started growing bluegrass.

It was the early 1960's. Erosion was cutting wheat yields, and the eroded areas were increasing year by year. In 1964, he began fighting back, switching some of his steepest, most erosion-prone cropland to lawn seed production.

Since then, Schultheis has sharply cut his topsoil losses and helped maintain his income. He says, "The seed provides me with a cash crop that's been as profitable as wheat the past 2 years."

He and his son Arthur farm about 800 acres in the Palouse region, near Colton. They keep about 200 to 250 acres in bluegrass, the rest in wheat, peas, barley, and lentils.

After 8 or 9 years, it's necessary to rotate bluegrass with other crops. "Eventually the soil gets sodbound and won't produce well," Schultheis says.

But in the meantime, growing grass aids in natural replacement of topsoil and has restored much of the fertility.

Soil erosion is a natural process, but it can be accelerated out of control in some areas by conventional tillage and other nonconserving farming practices.

And the consequences can be serious. Some scientists believe that lowered productivity from erosion is the most drastic problem farmers face today. And, of course, the abundance of food at reasonable cost to the consumer depends on productive agriculture.

Says the Agricultural Research Service's W. Doral Kemper, "On nearly one-third of this nation's 421 million acres of cropland, erosion annually exceeds 5 tons of soil per acre. Some of this land is losing up to 10 times more soil than is being replaced naturally." Kemper, based at Beltsville, Maryland, is national program leader for soil and atmospheric research aimed at curbing excessive erosion rates.

"On nearly one-third of this nation's cropland, erosion annually exceeds 5 tons of soil per acre. Some of this land is losing up to 10 times more soil than is being replaced naturally."

W. Doral Kemper, Agricultural Research Service

Five tons per acre per year is often considered the maximum tolerable rate (T) of soil loss. Spread out over an acre, this amount would be an almost imperceptible three-hundredths of an inch—less than the thickness of a dime. One reason that 5 tons is deemed tolerable is that it approximates the replacement rate in some soil types. Rangeland and semi-arid to arid land has a much lower replacement rate and a correspondingly lower T level.

Keeping erosion to the T level should enable farmers to grow high yields economically and indefinitely. But this rate is hard to attain on fragile lands and with intensive tilling, according to Robert I. Papendick, a soil scientist at the ARS Land Management and Water Conservation unit, Pullman, Washington.

The more soils are tilled, the more they erode, says Papendick. In fact, mechanical tillage is the single greatest cause of soil erosion because it breaks down natural soil bonds and exposes soils to wind and water's cutting action.

Retiring Erosion-Prone Land

While switching crops worked for the Schultheises, it may not be the best solution for other farmers and in other areas.

A national approach to erosion calls for temporarily retiring 40 to 45 million acres of highly erodible land by 1990. Although nearly every state has land that qualifies, much of it is found in Mississippi; parts of Iowa, Kansas, Nebraska, and Texas; and eastern Washington. (Texas alone accounts for about one-fifth of the nation's cropland erosion, and many there fear another 1930's-type Dust Bowl.) The Conservation Reserve Program (CRP) of the 1985 farm bill is aimed at removing this highly erodible land from production for 10 years.

Farmers who participate in the CRP receive annual rental payments from USDA for 10 years on enrolled lands. In addition, USDA picks up half the cost of establishing a permanent conservation cover, such as grasses or trees. The annual rental payments, currently ranging from $40 to about $70 per acre, are compensation for removing the land from crop production. About 23 million acres have been enrolled so far.

Two other conservations provisions in the farm bill attack the problem of soil erosion from other directions. One measure discourages farmers from converting potentially erodible land, currently protected by grass or trees, to cropland. The other provides incentives to farmers who prepare and follow conservation plans for their cropland.

One of the key requirements of these provisions is pinpointing the locations of highly erodible land. To help local administrators determine these locations, scientists and engineers with ARS' Water Erosion Prediction Project (WEPP) are developing a computer program that will tell how much water-caused erosion can take place under differing crop management practices on a field-by-field basis. The technology will be ready for testing by USDA's Soil Conservation Service (SCS) in 1989 and

Left: In western Tennessee, where erosion rates are often four times greater than the rate of natural replenishment, a brief storm quickly removes topsoil from a cornfield. Photo by Tim McCabe. (TN 1117)

for use by SCS district conservationists and others in 1992.

"We expect WEPP to give us the ability to predict soil erosion under many conditions so we can select the best soil conservation methods to be used on cropland, rangeland, and forestland," says WEPP project leader, engineer Leonard J. Lane at ARS' Aridland Watershed Management Research unit in Tucson, Arizona.

Two ARS field teams are gathering basic data on soil erodibility. Agricultural engineer John Laflen at ARS' National Soil Erosion Research Laboratory in West Lafayette, Indiana, manages the cropland field research, and hydrologist John R. Simanton, at Tucson, heads rangeland field research.

Of the estimated 5 billion tons of soil eroded from U.S. croplands each year, water accounts for two-thirds, wind strips off the remainder.

In addition to erodibility, Simanton's team gathers data on vegetation density, effect of grazing, and condition of rangelands. "When completed, the WEPP model will be more accurate and will apply to a much broader range of conditions than the 25-year-old Universal Soil Loss Equation (USLE) program now in use," he says.

Last summer, Laflen and a team of 12 scientists and technicians tested 37 major types of cropland soils in 20 farming states. The team used a trailer-mounted rainfall simulator with ten 25-foot rotating booms to create their own ministorms. *[See cover photo.]* Special stereoscopic cameras mounted on the simulator provided three-dimensional photographs for charting water runoff and rill formation.

The goal is to help farmers, ranchers, and foresters determine how susceptible their lands are to water erosion and decide which management practices are necessary to keep erosion within acceptable limits.

TIM McCABE

Near Pullman, Washington, soil scientist Robert Papendick inspects straw remaining on a field from the previous year's wheat crop. This residue will be left on the surface during the current planting season as a mulch to hold the topsoil in place and retain moisture. (1085X1186-2A)

TIM McCABE

On conventionally tilled land in Washington's productive Palouse region, topsoil losses are easily recognized by the light shaded areas where wheat has not germinated on the tops and ridges of the hills. (WA 90,542)

WEPP scientists expect the program to be easy enough to run on a small portable computer for making onsite calculations. This feature should be available when the first version of WEPP is completed.

Of the estimated 5 billion tons of soil eroded from U.S. cropland each year, perhaps a third is stripped off by the wind. Wind-erodible land is also eligible for the Conservation Reserve Program. A project headed by engineer Lawrence J. Hagen at ARS' Wind Erosion Research unit in Manhattan, Kansas, aims at improving the accuracy of formulas for wind erosion. The system, known as the Wind Erosion Prediction System, or WEPS, takes into account wind speed and direction, soil characteristics, crop growth, types of tillage, and erosion mechanics.

New field collectors for flying dust and sand designed by ARS engineers at Big Spring, Texas, will provide data for WEPS. One model with eight 4-inch-thick, pie-shaped collectors captures windblown soil particles at various heights above the ground.

Mounted on a steel rod and looking something like ducks flying in a tight formation, the collectors' weather-vanelike tails keep them facing into the wind.

"One of these samplers yielded 3 pounds of sand and dust after an especially turbulent windstorm," says ARS' Donald W. Fryrear. "We plan to set up collectors like these in some of the windier parts of Alaska, California, Colorado, Michigan, Montana, Nebraska, and Wisconsin."

Low-Erosion Farming Techniques

Even if land is not selected to be taken out of production, there may still be a need for erosion control. Soil losses can be significantly reduced by conservation tillage practices, including no-till, reduced or minimum tillage, ridge tillage, stubble mulch, and other forms of residue management. Research has shown that conservation tillage can reduce production, usually often without lowering crop yields.

Using no-till methods, the farmer never turns the land over or loosens it. "With no-till, stubble and straw residues, remnants of the previous year's crop, are left on the ground," says ARS' Papendick. "Stubble helps with its root system to hold down topsoil, and straw and other surface residues protect soil from the beating action of raindrops and keep it from washing away."

DOUG WILSON

Hydrologist Keith Saxton watches a new no-till seed drill developed by the ARS Land Management and Water Conservation Unit, Pullman, Washington. The drill places seeds without greatly disturbing erosion-preventing residues on the surface. (1087X1109-4)

Rather than digging furrows to put the seed in, no-till drills cut thin slits through the residues into the land. Farmers using this system can plant seed and fertilizer in one pass through a field.

One successful conservation tillage user, Mort Swanson, says, "There's a big difference in the color of the ground since we started using no-till in 1974. After 3 or 4 years of continuous no-till, the yellow, bare areas of exposed clays on the tops and sides of our hills are gradually disappearing. We're getting more earthworm activity and better water intake. You can feel the sponginess of the soil as you walk over it."

Swanson farms near Palouse, Washington, about 10 miles west of the Idaho border. He grows peas, lentils, barley, and wheat in a legume-grain rotation on about 1,200 acres of moderate to very steep farmland.

Few of Swanson's neighbors have switched to no-till, however. He says, "It's a completely different style of farming. No-till equipment costs can be high. "But over the long run, I've invested less under no-till than I ever would have using conventional tillage."

ARS researchers are hard at work on the cost problem, too. A powerful new, no-till seed drill that readily cuts through thick accumulations of surface residues could help prevent erosion on millions of acres of cropland across the United States. The new planter is being tested by scientists and engineers at the Land Management and Water Conservation unit, Pullman, Washington. It could wind up costing farmers two-thirds of what it now does to own and operate the larger, heavier no-till drills currently in use.

Other ARS-sponsored research to control erosion includes:

• A soil stabilizer, made from cornstarch, combats wind and water erosion by binding sand, silt, and clay into larger, erosion-resistant granules. The process was developed by William M. Doane and coworkers at the Northern Regional Research Center in Peoria, Illinois. Highway departments and construction contractors will likely be the first users of the starch-based stabilizer, until it can be made cost-effective for farmers.

• Lasers beamed to the ground from low-flying aircraft could help change the way farmers and soil conservationists measure soil erosion, according to Thomas J. Jackson, ARS hydrologist at the Beltsville Agricultural Research Center in Maryland. The lasers could provide reliable new estimates of the amount of erosion caused by small, short-lived gullies. Called ephemeral gullies because they disappear with the next cultivation or even with the next rain, they can cause an acre of land to lose 15 tons of soil a year.

• Studies show that irrigators in the Northwest could reap more dollars by plowing less and using crop rotations that can cut irrigation needs by 30 percent and erosion by 90. ARS scientists at the Snake River Conservation Research Center in Kimberly, Idaho, say many farmers now make 15 tillage trips to grow 2 years of dry beans after 3 years of alfalfa.

That's 12 trips too many, they say. Their alternative cropping system—replacing the conventionally tilled beans with no-till wheat, barley, or corn, then minimum-till corn or beans—needs only two or three trips. "We found the system could save growers an average of $122 an acre compared with the same rotation grown with conventional tillage," says soil scientist David L. Carter at the center.

• Research at the Western Regional Research Center in Albany, California, will see if the same beneficial fungi that stimulate root growth can also prevent erosion. In greenhouse tests, soil colonized with mycorrhizae was better aggregated, more porous, and more permeable to water, and thus less prone to erosion than uncolonized soil.—By **Howard Sherman,** ARS.

W. Doral Kemper, National Program Leader for Soil and Atmosphere Research, Room 238, Bldg. 005, Beltsville Agricultural Research Center, Beltsville, MD 20705 (301) 344-4034. ♦

Future Lawns To Save Mowing Time

Hate mowing and watering the lawn? Hang in there.

Jack J. Murray, who tends some 3,000 experimental lawns, has a few that need less watering and only a third as much mowing as conventional lawns.

"These are the precursors of what America's lawns will be," says Murray about his checkerboard of 3- to 6-foot square test plots at the Beltsville, Maryland, Agricultural Research Center. "Americans spend countless hours and over $24 billion a year on their lawns."

Murray is a turf specialist with the Agricultural Research Service.

One new turf in the final stages of testing is a zoysia grass that will be sold as seed rather than the more expensive zoysia plugs that homeowners now buy and plant.

"This zoysia needs to be mowed only one third as often," Murray says. "Some zoysias tend to grow sideways, spreading out to cover the ground, and they tolerate drought."

He is also working on lawn seed mixtures of zoysia and tall fescue that would stay green year-round. Today's zoysia varieties are mostly suited for southern states; zoysia lawns in the north turn brown over winter.

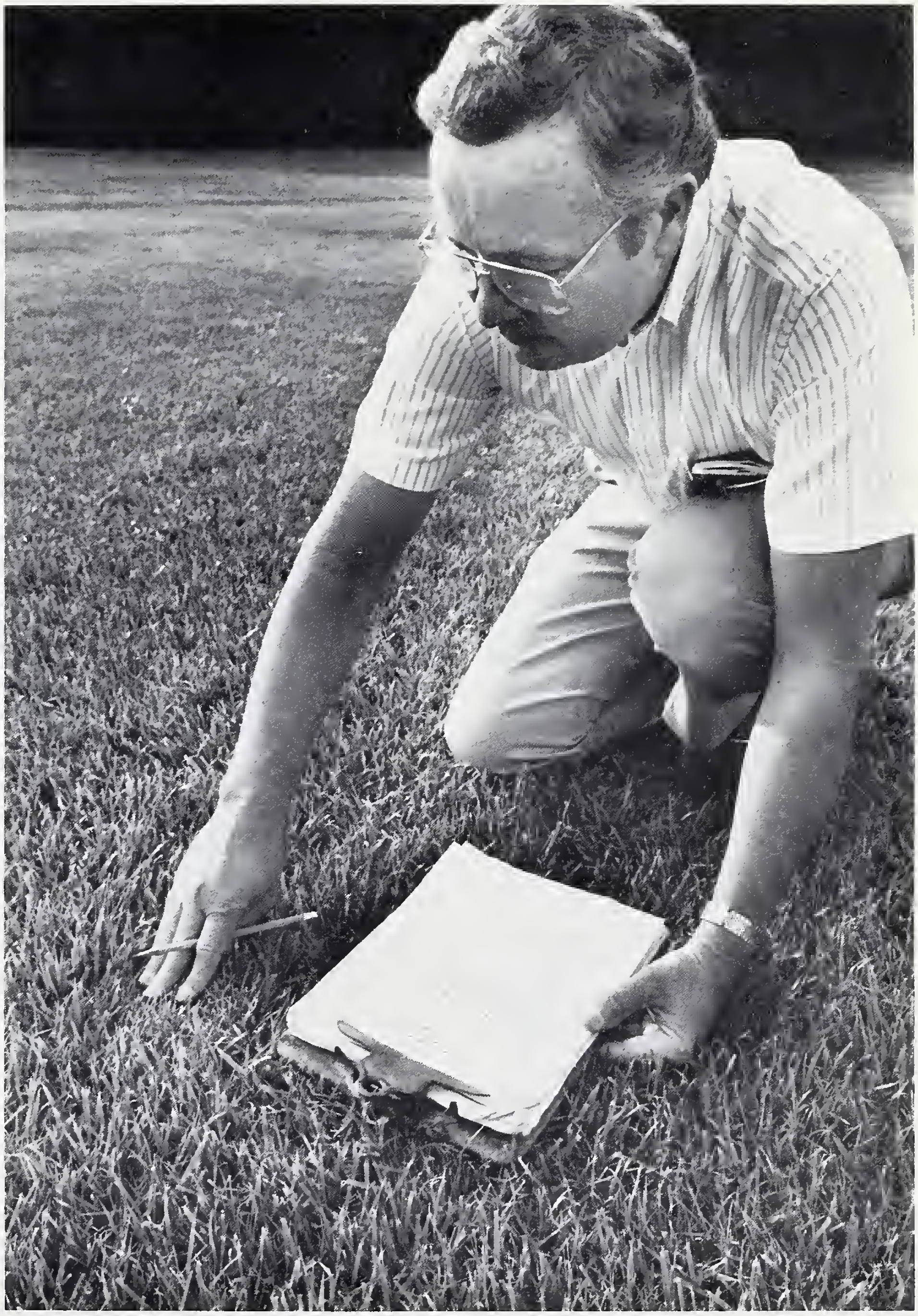
According to Murray, the zoysia seed in the mix will keep grass green in the summer, and in many locations, the fescue will keep it green all winter. An experimental mix of the two grasses is undergoing final testing.

Besides zoysia, Murray is testing hundreds of tall fescues, fine fescue, perennial ryegrasses, bermudagrasses and Kentucky bluegrasses on the Beltsville plots.

Murray evaluates new types of lawn grasses for disease resistance, vigor, smooth and even growth, and cold or heat tolerance, as well as for their rooting power or blade width that give the lawn a carpeted appearance.

Seed companies use his evaluations to name and market new varieties of turfgrasses for homeowners and landscapers.

One of Murray's specialties is turf grass for sports fields. "Athletic directors will find that the newer sports turf varieties stay locked into the earth and can't be uprooted as easily during football or baseball games."



BOB BJORK

Agronomist Jack Murray checks growth of a mixture of zoysia and tall fescue that remains green year round. Murray has some 3,000 experimental lawn plots at the Beltsville Agricultural Research Center in Maryland. (0887X927-30)

Information on new varieties and their uses is available from garden centers, rural feed and seed stores, and from USDA extension offices.—By **Stephen Berberich,** ARS.

Jack J. Murray is in the USDA-ARS Germplasm Quality and Evaluation Laboratory, Bldg. 001, Room 335, Beltsville Agricultural Research Center-West, Beltsville, MD 20705 (301) 344-3655. ♦

Oats Are Not Just for Horses

Grandmother was right—oatmeal is good for you. In fact, she was more right than she knew, in light of recent research indicating that eating oats can reduce cholesterol levels and may mitigate diabetes.

Nutritional benefits are a major reason for refocusing attention on oats by the Agricultural Research Service, says Charles F. Murphy, national program leader for grain research for ARS.

Murphy points to industry-sponsored research showing that for those with high serum cholesterol, eating 2 ounces of oats a day and a diet low in saturated fats can appreciably lower blood cholesterol levels.

For every 1-percent drop in blood cholesterol levels, there is estimated to be a 2-percent drop in a person's risk of dying of heart disease, according to the American Heart Association.

Oats actually provide one of the best packages of all-around nutrition of the cereal grains, according to Murphy. Its amino acid balance is excellent and the protein level is high, while the fat is polyunsaturated.

"We've always known oats had good nutritional value, but all of the new information coming out indicates it is better than expected," Murphy says. "This creates a need to look at oats with modern research techniques. The day is past when you thought of oats as just a feed for race horses or as an ingredient for porridge and cookies."

With research, it may be possible to develop varieties of oats with higher levels of beta-glucan, the cholesterol-lowering factor, so they could serve as a pharmaceutical source of the substance.

Outlook for Oats

• **Nutrition:** At the Agricultural Research Service's Western Regional Research Center in Albany, California, scientists are planning to further investigate the ability of oats to lower cholesterol levels.

Food scientist Antoinette Betschart and a team of researchers are also interested in studying other possible physiological effects of oats, such as indications that oat fiber may help control diabetes to some extent by preventing erratic swings in blood sugar levels by slowing the rate of carbohydrate digestion in the intestine.

• **Beta-glucan:** At the ARS Cereal Crops Laboratory in Madison, Wisconsin, plant physiologist David M. Peterson has proposed screening large numbers of oat varieties to find those with high levels of beta-glucan, the component of oats suspected of providing the cholesterol-lowering benefit. Those with naturally high beta-glucan levels could then be further enhanced by selective breeding to create a potential specialty crop to use as a pharmaceutical source of the substance or at least reduce the amount of oats people would need to eat to lower their cholesterol.

The Madison laboratory is also planning to study the chemistry and synthesis of the beta-glucan with the long-term goal of enhancing beta-glucan levels through genetic engineering.

• **Tailoring oats:** Researchers have begun working on oat varieties with an enhanced trait or package of traits that could meet special marketing needs such as high protein, high oil content, or high beta-glucan level.

To support this research, ARS has started a major project to screen the 20,000 oat lines represented in the National Small Grain Germplasm Collection under the direction of agronomist Leland W. Briggle. A major portion of field and laboratory studies is being conducted under the direction of ARS agronomist Darrell M. Wesenberg, based at the University of Idaho Research and Extension Center in Aberdeen.

• **Oat oil:** Increasing the level of oil in oats would increase the available energy. A high protein level and increased energy would make oats much more attractive as a livestock feed.

The oil in oats is essentially polyunsaturated fat. Some research in Australia and the British Isles has indicated that feeding animals a diet high in oats can change the cholesterol level of eggs, milk, and meat, according to Vernon Burrows, chief of the cereal section of the Plant Research Center, Agriculture Canada, in Ottawa.

If the oil level can be raised to 17 percent without reducing overall yields, oats would also have potential as a commercial oil crop for human consumption. Oat lines with 15 percent oil content have already been developed, says agronomy professor Kenneth J. Frey of Iowa State University, who is working cooperatively with ARS.

• **Protein level:** Researchers are working on increasing protein levels in oats. The crop already has one of the best amino acid balances among the cereal grains. It should be possible to raise the protein content to 20-25 percent, which would make it a source of protein in the diet for many Third World countries, according to Frey.

• **Farmer opportunity:** While the same soil and climate that produce corn, soybeans, or wheat will grow oats, many U.S. farmers limit their oat planting to marginal land because the crop does not yield the same economic return as other field crops, according to Murphy.

Tailored varieties of oats that could serve specialty markets would increase oats' commercial potential. Also, research projects on increasing oats' overall yield could make the crop more attractive to farmers.

Improved management practices and varieties could greatly improve the efficiency of production. For example, new oat selections already developed yielded as high as 246 bushels per acre in experimental trials under favorable irrigated conditions at Aberdeen in 1987 compared with an average yield in the state, one of the highest in the nation, of 73 bushels per acre.—**K.K.**

Also, new oat varieties with high protein content could serve meat-poor countries as an important source of dietary protein.

"We're not so much looking for a single 'super oat,'" Murphy says, "as we are developing and improving lines to serve particular purposes." Renewed attention is also being paid to oat research because, along with their nutritional merit, oats could represent a good alternative crop for farmers growing other cereal grains.

"Oat prices to farmers are regularly high enough to meet target levels set by the federal farm bills—the only cereal grain to do so," Murphy says.

The United States grew about 386 million bushels of oats in 1986. Another 33 million bushels were imported from Finland, Sweden, and Canada.—By **Kim Kaplan**, ARS.

For further information, contact Charles F. Murphy, USDA-ARS Plant and Natural Resources Sciences, Room 240, Bldg. 005, Beltsville Agricultural Research Center, Beltsville, MD 20705 (301) 344-1560. ♦

Upcoming in the May Issue

• Scientists tackle the specialized problems of Puerto Rican agriculture—rainfall, terrain, small farms—while boosting the Caribbean Basin Initiative.

• Getting set to turn the Texas wind into electricity, the nations largest experimental vertical axis wind turbine undergoes tests this spring.

• The children of the people in a famous 1950's heart study are now helping scientists nail down the ABC's of coronary artery disease.

Corn Bred Successfully for Higher Photosynthesis Rate

For the first time, lines of corn have been successfully bred for higher rates of photosynthesis, a trait directly translating into higher yields, an Agricultural Research Service scientist reports.

Doyle B. Peters, a soil physicist with ARS at Urbana, Illinois, says at the conclusion of a 7-year field experiment, "There is no doubt that we have bred corn that manufactures its food more efficiently."

Breeding into the corn an increase of less than 2 percent in the rate of photosynthesis resulted in a synthetic line that outyielded the starting pool synthetic grown in the same field by 17 percent, or in this case by 20 bushels per acre. The higher yield is particularly notable because inbreeding traditionally decreases yields due to lack of vigor.

The higher yield of the new line was completely attributable to an increase in kernel size rather than changes in the number of ears of corn, Peters says.

He cautions, however, that it is hard to quantify precise increases in photosynthetic rate because of climatic variations from year to year. "In years when yields were down for corn in general, the higher rate of photosynthesis barely showed up in the yields."

Breeding crops for higher rates of photosynthesis is a quest that has eluded scientists for many years, Peters says, adding that "it may not be possible with most crops, at least not with standard breeding techniques."

But Peters has succeeded with corn using just those techniques. He says, this experiment proves two things. First, enough variation exists in some of the higher plants—corn, sugarcane, and sorghum—to allow us to select and breed them for somewhat higher rates of photosynthesis. These are plants that appeared relatively late in evolution in the Tropics, and they carry out photosynthesis somewhat differently from early plants. Second, it proves a direct connection between increased photosynthesis and crop yields.

Photosynthesis is the photochemical process that green plants and certain other organisms use to manufacture food. Expressed simply, Peters says,

"There's no doubt that we have bred corn that manufactures its food more efficiently."

Doyle B. Peters, Agricultural Research Service

when sunlight energizes the chlorophyll in a leaf, it starts a process that transforms carbon dioxide and water into oxygen and glucose or simple sugar. This is the fundamental biological process that keeps plants and animals alive. While it can be described in a few words, it is actually an extremely

continued next page

TIM McCABE

A technician throws the switch on a mobile field chamber capable of measuring the rate of photosynthesis in experimental corn plots near Urbana, Illinois. Each measurement takes about 40 seconds as the plastic-enclosed chamber moves along rails from plot to plot. (0687X697-20)

complex affair involving thousands of reactions. Until the middle of this century, we knew little about how it takes place, and we are learning more about the process all the time.

Peters says that photosynthesis is not a very efficient process, adding that even a small increase in efficiency could mean a very large increase in food production.

To make the Illinois experiment possible, Peters designed and built motorized plastic chambers that move through a cornfield on rails, pausing for 40 seconds over each experimental plot of 18 corn plants.

When the chamber moves into position over a corn plot, plastic sides drop down, sealing off a 60- by 80-inch area. Sophisticated instruments inside the chamber measure carbon dioxide loss and the increase in atmospheric water. These two readings are recorded on a computer.

Other equipment continuously records the total radiation from the sun striking the field as well as the wavelengths hitting the uppermost leaves that are directly involved in photosynthesis.

These measurements enable Peters to determine the photosynthesis rate as a function of light intensity.

Corn for the tests was selected by D.E. Alexander, University of Illinois plant geneticist, from an Illinois variety of a stiff-stalk corn developed at Iowa State University. This gene pool is the source of inbreds that make up at least half of the genetic material now in central Corn Belt hybrids.

Alexander described the experiment as "a classical recurrent selection program"—one in which corn plants with high photosynthetic rates are selected each year and used in further breeding.

"Working against increases in yields," Alexander says, "were the effects of inbreeding, which decreases plant vigor."

He points out, however, that despite considerable inbreeding in this experiment, its effects have been more than offset by increases in photosynthesis.

To rule out factors other than photosynthesis efficiency affecting corn growth, Peters deployed a battery of instruments in the cornfield to measure as many other variables as he and his associates could think of.

Data was transmitted to two trailers full of computers and continuous graph recorders. Among other things, Peters tracked temperature of air, soil, and the upper leaves of plants; dewpoint; and carbon dioxide concentration in the field.

"The measurements have taught us a lot about factors affecting corn growth," Peters says. "Nights here are typically still, and we found that carbon dioxide emanating from soil bacteria and the plants themselves builds up in the field until by dawn the amount of the gas in the air is nearly twice normal."

Morning breezes usually blow away the excess carbon dioxide, but when this fails to happen, and the sun heats up the leaves, the rate of photosynthesis starts climbing. "We have to throw out these exceptional readings and wait for carbon dioxide levels to return to normal," Peters says.

Peters says that his experiment has also shown that corn plants with high photosynthetic capability are better able to use light at high intensities.

"On a bright summer day, the chlorophyll of most plants becomes saturated with light, sometimes before noon. Corn plants with high photosynthetic rates don't become saturated quite so early in the day."

Peters also says he has learned that "the best corn years are those with a warm, dry spring and a cool August, with plenty of rain, since August is ear-filling time. Unfortunately, we don't often have summers like that in the Corn Belt."—By **Hubert Kelley,** ARS.

Doyle B. Peters is in USDA-ARS Crop Management Systems Research, S-216 Turner Hall, 1102 South Goodwin, University of Illinois, Urbana, IL 61801 (217) 244-6251 or 244-4352. ♦

Counting Insects: The High-Tech Way

TIM McCABE

Being the nearly blind creatures that they are, bats locate an object—whether it be a juicy insect to eat or a cave wall to avoid—by sending out sound waves and waiting for echoes to bounce back. Taking the bat's lead, an Agricultural Research Service scientist has invented two devices that do the same to detect flying insect pests in crop fields.

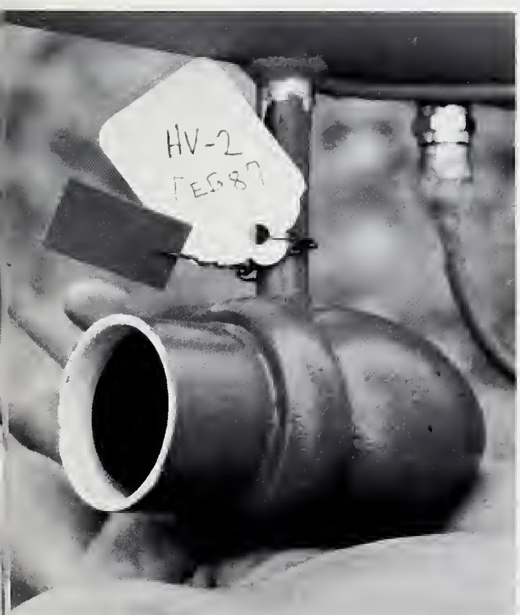
The roll-call system, dubbed "sodar" for sound detection and ranging, or a second system whose infrared light detects moths, can alert farmers that moths are active, and they should look closer for an onslaught of insect pests in their crops.

"Accurate counts eliminate unnecessary pesticide use," says Don E. Hendricks, an entomologist who invented the high-tech counters at the Subtropical Agriculture Research Laboratory in Weslaco, Texas.

In tests near corn and cotton fields in south Texas, Hendricks found that both devices counted insects with 92 percent accuracy. The kind of insect to be counted can be varied by changing pheromones. "The corn earworm pheromone does not appeal to the cabbage looper or vice versa, so the devices are very selective," he says.

The sodar device looks like a rocket, and for good reason. A rudder orients the device into the wind and the pheromone wafts downwind. Male insects

TIM McCABE



TIM McCABE

Top, left: Near Weslaco, Texas, entomologist Don Hendricks (right) and technician Carlos Perez test infrared sensors used to count flying insects lured into this wire-mesh cone by a sex pheromone. When an insect breaks an infrared beam at the top of the cone, the sensor sends a signal to a nearby computer. Large signal counts indicate that insect populations may be threatening crops. (0387X162-19)

Above: After a night of counting insects near a cornfield, a sound detection and ranging sensor is inspected by entomologist Don Hendricks (right) and technician Carlos Perez. (0387X167-22)

Left: Closeup of the echo receiver and insect pheromone dispenser mounted under a sodar unit. (0387X168-4)

pick up the scent and follow it—right to the echo receiver. Each echo causes one radio signal to be sent to a receiver and computer located away from the field.

The other device is a basic cone trap baited with a pheromone that has been modified for counting. The pheromone attracts a male and as he realizes it's a false alarm and that there's no female for mating, his instinct is to fly up—into the wire-mesh cone. With Hendricks' modification, as the insect goes up, instead of being trapped for later visual counting, he passes through an infrared light beam; each interruption registers one insect. Again, a radio signal is sent to a receiver.

Hendricks drew up a general outline for a computer program that tallies insects detected and tells a farm manager when a population might be getting high enough for closer inspection and possible pesticide use. Mark Pendergast, a computer specialist for General Motors Corporation, wrote the computer program.

Hendricks designed the devices that can detect and count the moths of several major pests—tobacco budworm, corn earworm, cabbage looper, fall armyworm, southwestern corn borer, and sugarcane borer.

"These systems could pay for themselves in a year or two with the money saved in labor needed to count insects," Hendricks says.

The sodar unit is patented. For information on obtaining an exclusive license to manufacture this or other USDA patents, contact the coordinator of the National Patent Program. *[See page 16.]*—By **Jessica Morrison,** ARS.

Don E. Hendricks is in USDA-ARS Subtropical Cotton Insects Research, P.O. Box 267, Road 1015 South, Weslaco, TX 78596 (512) 565-2647. ♦

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PATENTS

Wetting Agent Unbungles Fungals

Scientists have recently noted that several species of fungi produce natural weed killers *[see "A Fungal Foe for Jimsonweed,"* Agricultural Research, *January 1988]*. But before these natural controls can be effectively exploited, ways must be found to improve their convenience and reliability.

Until now, the need to keep fungal herbicides in contact with dew or else to mist them with droplets of water has limited fungal herbicide's practicality. For if the fungal agent isn't kept wet for several hours after application, it won't grow and produce weed-killing toxins.

Now there's a spray that can be applied to undesirable vegetation that enables fungi to germinate and grow without dependence on unpredictable dew or laborious misting.

The spray is made of a water/oil emulsion containing special additives to help get the herbicidal fungi started—a combination of lecithin with wax and/or a calcium salt. Weeds may get the patent-applied-for formula either in mixture with the fungus or immediately after they are inoculated with the fungal pathogen.

For technical information, contact Charles Quimby, Jr., USDA-ARS Delta States Research Center, P.O. Box 350, Stoneville, MS 38776. *Patent Application Serial No. 07/114,952, "Control of Undesirable Vegetation."*

Dyeing Flame-Retardant Fabrics

There are ways of processing cellulosic fabrics such as cotton and rayon, plus certain cellulosic blends, so they will be flame retardant. These processes affix the hydroxymethyl phosphonium-nitrogen polymer to the cellulosic fabric substrate.

The commercial process has two undesirable aspects. First, it requires the use of gaseous ammonia in the finish, thus requiring special equipment and processing to control this noxious gas. Second, because these fabrics will no longer retain colors or take up dye as well as untreated cotton fabrics, it is possible to offer the consumer only a limited selection of colors. For the consumer, it amounts to a trade off: the added safety that flame retardancy brings in exchange for limits on color selection and durability.

But producers and consumers may yet have a better world. ARS scientists have applied for a patent for a process that replaces the gaseous ammonia in the finish with urea. This new finish can be run on standard textile equipment. Second, this finish changes the character of the phosphorous-nitrogen polymer so that it interacts with dye to a lesser extent than finishes based on ammonia.

Advantage has been taken of the positive, or cationic, electronic character conferred by the polymer system to devise substantially different procedures for dyeing flame-retardant fabrics. These procedures, based on bonding between the cationic charge of the polymer and the anionic charge of the dye, extend the range of colors and types of dyes that can be used on these flame-retardant fabrics. In addition, they provide a means of renewing the colors of such fabrics.

For further information, contact Robert J. Harper, Jr., and John V. Beninate, USDA-ARS Southern Regional Research Center, P.O. Box 19687, New Orleans, LA 70179. *Patent Application No. 07/075,169, "Process for Dyeing Flame-Retardant Fabrics."*

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Copies of existing patents may be purchased from the Commissioner of Patents and Trademarks Office, Washington, DC 20231. Copies of pending patents may be purchased from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161. ♦